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Governor

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DEPARTMENT OF ECOLOGY
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MEMORANDUM
February 25, 1983

To: George Houck, Industrial Monitoring Section

From: Dale Clark, Water Quality Investigations Section DC

Subject: Rennie Island Discharge (1981-1982)

INTRODUCTION

On January 20, 1981, I met with you, John Bernhardt, and Tim Determan to discuss the feasibility of a receiving water survey in Grays Harbor (segment No. 10-22-04). You requested the survey in order to:

I. evaluate the impact of discharging spent sulfite liquor from the ITT Rayonier detention ponds on Rennie Island into the Chehalis River/Grays Harbor estuary; and

II. perform a quality assurance evaluation of ITT Rayonier laboratory analyses.

The survey request was received on short notice. The work would have to be performed within two weeks of the above-mentioned meeting. It was therefore decided that management recommendations would be made based on an initial review of the data collected, then other priority and previous staff commitments would be considered in completing the final report.

BACKGROUND ON SULFITE WASTE LIQUOR

Sulfite waste liquor (SWL), a by-product of the sulfite paper pulping process, contains components that are toxic to aquatic life and have a high biochemical oxygen demand (BOD). When SWL is discharged untreated into receiving waters, high BOD can pose a threat to aquatic life by depleting the oxygen that is otherwise available for respiration. In nature, bacteria break down the components in the SWL while consuming available oxygen. In a worst-case situation, this could result in anoxic conditions.

LOCATION AND DESCRIPTION OF STUDY AREA

Grays Harbor is a large, pear-shaped estuary located on the southwest coast of Washington State. It is 46 miles north of the mouth of the Columbia River and 135 miles south of Cape Flattery. The harbor is characterized by expansive mud flats and intervening channels created by many rivers and creeks that discharge into the estuary. The estuary is divided into two major channels -- the north and south. Surface area of Grays Harbor from its mouth to Montesano is 1.06×10^9 ft^2 (38.03 square miles) with a volume of 13.66×10^9 ft^3 at mean lower low water (MLLW) and 2.53×10^7 ft^2 and 37.13×10^9 ft^3, respectively, at mean higher high water (MHHW) (Stein, Dennison, and Peterson, 1966). The north channel, the principal area of investigation, is used for navigation and has been dredged by the U.S. Army Corps of Engineers to an approximate depth of 35 feet with a width of 350 feet. The major rivers that discharge to this area are the Hoquiam, Wishkah, and Chehalis.

Rennie Island is located in the middle of the Chehalis River off the City of Hoquiam. The island separates the river into the north and south channels. An impoundment exists on the island which is used for storing effluent from the ITT paper mill. A submerged pipeline which transects the north channel connects the ponding basin to the mill. The impoundment is no longer used to store effluent except under emergency conditions such as described in this paper (Figure 1).

The Department of Ecology Water Quality Standards (1977) state that upper Grays Harbor is Class B marine. The main body of the harbor is Class A with oyster production being one of the main beneficial uses. The line which separates the two areas is located about west of Rennie Island extending between Point New and about Johns River.

ITT RECOVERY FURNACE BREAKDOWN

In November of 1980 the ITT Rayonier kraft mill located in Aberdeen had to shut down its sulfite waste liquor recovery furnace for unexpected repairs. The furnace contains 1,800 heat exchange tubes that during the past 15 years of operation became corroded, finally resulting in failure. Upon inspection of the furnace, it was determined that approximately 1,400 of the tubes would have to be replaced (Houck, 1981). The repair required a lengthy shutdown period during which the waste liquor had to be disposed of in an alternate manner if the plant was to continue operation.

Status of the recovery furnace as of March 1982 is that repairs have been completed and the furnace has been placed on standby awaiting increased production at the paper plant. Recent downturns in the paper market have necessitated a decrease in paper production from an average of 650 tons per day in early (January) 1981 to 320 tons per day since January 1982. At present, all of the SWL is routed to on-site plants for the production of vanilla flavoring, cattle feed, or silva chemicals (chemicals derived from trees; e.g., drilling mud) (Houck, 1982).

The Department of Ecology and ITT Rayonier came to an agreement on the discharge (Enforcement Docket No. DE 80-696) whereby wastewaters would be piped to the impoundment on Rennie Island (Figure 1). After a retention period, the SWL would be discharged to the river by diffuser under the following agreed-upon conditions:

1. Discharge on ebb tide only;

2. River flow must exceed 5000 cfs as determined by the United States Geological Survey (USGS) from river flow data collected upstream (Loehr and Collias, 1981). This is accomplished using the following formula:

   Flow at Aberdeen = [Chehalis at Ground Mound + Satsop] x 1.5 + Wynochee.

3. Dissolved oxygen (D.O.) in the harbor must remain above 7.5 (mg/L) or 75% of saturation, based upon which parameter is the worst case; and

4. BOD must not exceed 50,000 lbs/day at the minimum river flow of 5,000 cfs. The lbs/day of BOD may increase on a sliding scale based upon river flow with a dilution ratio resulting in ≃ 2 mg/L BOD in the receiving water.

It was further agreed that discharge from Rennie Island would commence on January 1, 1981, and cease on or before March 15, 1981. Since the recovery furnace repairs were completed in 1981 after March 15, discharge was necessary during the fall of the year in order to empty the impoundment. Also, in accordance with the aforementioned WDOE docket, discharge had to commence on October 1, 1981, and be discontinued on March 15, 1982, or when the impoundment was emptied, whichever occurred first. Emptying of the impoundment was completed on November 28, 1981. Since that time, the discharge line valve has been left open allowing water from the harbor to enter and leave the holding basin during tide cycles further flushing the impoundment.

METHODS

The study included four parts conducted during January 26 - February 3, 1981: (A) reconnaissance survey; (B) fixed-station sampling; (C) drogue sampling; and (D) quality assurance. WDOE and ITT split samples as part of much of the sampling. Samples were collected with a Kemmerer (ITT) and Van Dorn (WDOE) sampling apparatus. Samples were taken at near surface and a depth of 10 meters for laboratory analysis. In addition, parameters were measured *in situ* using a Hydrolab model 8000 (ITT) and a Beckman Induction Salinometer RS 5-3 (WDOE).

The fixed-station locations were the same as those used by ITT (unless otherwise noted) on their routine monitoring runs performed three times a week to assess water quality in the upper Grays Harbor estuary. The locations of the sampling sites are shown in Figure 1 and described in Table 2.

Sampling began 2.5 hours after the initial Rennie Island discharge. The purpose of the time lag was to allow an equilibrium to occur in the sampling area. Sampling began at the downstream station and proceeded upstream with the exception of Stations W-1 (Wishkah River) and C-1 (Chehalis River) which were sampled on the morning of February 3, 1981 prior to the regular run.

Samples from stations 001 through 005 (fixed stations) were collected for two consecutive days and stations D-1 and D-2 (drogue study) for one day. The samples were split between WDOE and ITT. Additional sampling points upstream (Stations W-1 and C-1) were analyzed by WDOE to determine background water quality values necessary for determining impact on the water quality by the discharge (Figure 1).

A. <u>Reconnaissance Survey</u>

During the week of January 26-30, 1981, Tim Determan and I traveled to Grays Harbor to familiarize ourselves with the study area. Several objectives were to be accomplished: (1) locate the Rennie Island outfall; (2) establish receiving water sampling locations; and (3) familiarize ourselves with general characteristics of the survey area.

In order to determine dispersion and dilution characteristics of the Rennie Island discharge, 250 ml of Rhodamine wt dye was added to the effluent. This method did not prove satisfactory as the dye either did not surface in the receiving waters or was not detectable above background coloration. As an alternate method (Mike Woods, personal communication), oranges were added to the effluent. These slightly buoyant fruit surfaced in the river below the outfall. This location was marked with an anchored buoy.

B. <u>Fixed-station Sampling</u>

On February 2-3, 1981, a water quality survey was carried out at the stations established by ITT Rayonier Paper Company and WDOE. The purpose was to:

1. Establish and sample two control stations; one each in the Chehalis River (C-1) and Wishkah River (W-1) upstream from the Rennie Island discharge (Figure 1).

2. Sample at ITT Rayonier Paper Company monitoring stations (001 through 005) to correlate with data obtained from

WDOE stations (C-1 and W-1) and drogue stations (D-1 and D-2). Both WDOE and ITT personnel sampled these stations with the exception of W-1 and C-1 (WDOE only).

Please refer to Table 1 for description of parameters and types of analysis.

C. Drogue Study

On February 3, 1981, a study was carried out by WDOE to evaluate changes in a given water mass as it moved downstream from the Rennie Island discharge. The drogue was deployed where the oranges had surfaced 25 yards off shore from Rennie Island (Figure 1, D-1). A sample was collected at the time of release (see Table 1 for list of parameters, footnote 2). Samples were collected at intervals of five minutes as the drogue was followed. Water was collected at the surface and 10 meters using a Van Dorn bottle and split with ITT for comparative analysis.

Bearings were taken using a hand-bearing compass to fix the drogue location for map plotting purposes. The study was conducted on an ebb tide when tidal energy and river flow were very high.

D. Quality Assurance

The purpose was to:

1. Perform a quality assurance check on the ITT Rayonier laboratory by performing analyses on split samples at our Tumwater laboratory; and

2. Perform a quality assurance check on the ITT Rayonier *in situ* instrument (Hydrolab 8000) by WDOE laboratory analysis and in-field instrument comparison (Beckman RS 5-3).

The methods employed for each of the above sections are described in Table 1. The table lists the parametric coverage and rationale for measuring each for all four parts of the study and compares the different methods of analysis used by the participants.

RESULTS

The results of the fixed-station and drogue studies are jointly presented in the following section (I). Section II discusses the quality assurance aspects of the survey. The data for the three efforts are summarized in Tables 2 and 3.

I. Fixed-Station and Drogue Studies

1. Water Quality Impact of Rennie Island Discharge

On February 2 and 3, river flow was sufficient to discharge from Rennie Island according to docket guidelines.

Water quality appeared to be good at all fixed stations used during the February 2-3, 1981, survey. The parameters pH (S.U.), turbidity (NTU), temperature (°C), and dissolved oxygen (mg/L, Winkler) were all within water quality standards for Class B waters including the special requirement that dissolved oxygen must exceed 7.5 mg/L or 75 percent of saturation. Salinity (o/oo), nutrients (nitrate-N, nitrite-N, orthophosphate-P, total phosphate-P, and ammonia-N, and water color (units) did not indicate conditions detrimental to water quality (Tables 2, 3, and 4).

Biochemical oxygen demand (BOD) was analyzed from effluent samples, taken just prior to discharge. The values obtained were converted to pounds per day and compared to limits set down in the enforcement docket. BOD levels for both days were within the limits of the docket.

Sulfite waste liquor levels above and below the outfall as determined by the Pearl-Benson Index (PBI) do not indicate a significant difference among values, with one exception: at station 001 where values were much higher. Elevated ITT PBI values (>50) at stations 002, 003, and 004 suggest that a water quality problem may exist at these stations; however, this may be an artifact of analytical methods as described in the discussion of PBI in the Quality Assurance section.

Drogue study results were based on two sampling locations. As previously stated, the study was conducted during ebb tide when tidal energy and river flow were very high. These two factors created a surface water velocity of approximately 300 feet per minute (3.4 MPA), displacing the drogue some 1,500 feet (457.4 meters) downstream before the outfall sampling could be completed (Figure 1, D 2).

Unfortunately, the water mass in which the drogue was entrained flowed under a log boom 1500 feet below the outfall. The drogue was lost at this point; however, it was apparent that the effluent remained close to the shoreline of Rennie Island for some distance below the outfall. This outcome suggests that any monitoring of river quality associated with the Rennie Island discharge should be carried out closer to the shoreline, quarter-point sampling should be employed, or that the outfall line should be extended farther out into the main channel. Existing sampling sites used by ITT Rayonier personnel are located in mid-channel (station 001 and 002, Figure 1) and appear to completely miss the effluent for at least 1,500 feet below the outfall.

2. Fecal Coliform (FC) Bacteria Levels in Grays Harbor and SWL Effluent

Fecal coliform (FC) bacteria are capable of surviving in receiving waters such as streams, lakes, rivers, and estuaries for some time. When found in receiving waters, they indicate fecal contamination by human or animal sources. One group of FC bacteria known as *Klebsiella* (KES) are capable of reproduction under certain conditions outside the body of a warm-blooded organism. One environment that produces the KES bacteria is certain sulfite mill processes from which they are eventually discharged along with the treated or untreated process water. Therefore, when a high concentration of KES bacteria is found in a receiving water, they may have originated from an industrial process. If sulfite mills are discharging to the waterway, the mills would be considered as a possible source.

The pooled FC values (16 samples) from the three surveys (two fixed station and one drogue) exceeded the state water quality standard of 200 org/100 ml limit for fecal coliform bacteria in Class B freshwaters ($\overline{X}$ = 345 org/100 ml, S = 203); four of the samples (25%) exceeded 400 org/100 ml. The median value of 345 org/100 ml was higher than the marine regulatory limit (Tables 2, 3, and 4).

Effluent samples taken from the Rennie Island discharge point displayed low levels of FC bacteria including *Klebsiella* (3 org/100 ml on February 2, 1981 and less than 1 org/100 ml on February 3, 1981, Tables 2, 3, and 4). The low values indicate that the Rennie Island discharge was not the cause of the FC water quality violation found in upper Grays Harbor during the survey.

II. Quality Assurance

The results from fixed-station and drogue study sampling were compared. A two-way analysis of variance (ANOVA) without sample replication was used to satisfy the quality assurance portion of the study (Table 4) (Sokal and Rohlf, 1969).

Data were analyzed for both days to determine if there was a significant difference between the ITT and WDOE results. Five parameters showed a significant difference between the ITT and WDOE laboratories and five parameters demonstrated no significant difference (Table 5).

Differences in laboratory results with such a small data base are difficult to analyze. Some of the variation in the samples when significantly different results were obtained may be explained by analytical technique as explained in the following text:

1. pH (February 2-3, 1981) - split samples were not used for this parameter. The ITT Rayonier analysis was conducted *in situ* with a model 8000 Hydrolab while WDOE grab samples were placed on ice and analyzed the next day at the WDOE laboratory, with a Corning Model 135 pH meter. Different water masses sampled by the two groups and the delayed analysis of the WDOE samples, which may have resulted in pH changes over time, could be the cause for the difference between the observed values.

2. Turbidity (February 2, 1981) - split samples were used for analysis of this parameter. WDOE data were consistently higher, about two times the ITT value (WDOE $\overline{X}$ = 22.1; ITT $\overline{X}$ = 9.67, see Table 2). Possible explanations for the difference between laboratory results for this parameter are:

    a. Laboratory Instruments Variance.

       Both laboratories use a Nephelometer to measure turbidity. DOE used a Hach 18900-00 turbidimeter and ITT Rayonier used a HACH turbidimeter (unknown model no.).

       Nephelometers are secondary instruments used to measure nephelometric turbidity units (NTU). Because of fundamental differences in optical systems, the results obtained with different types of instruments may not check closely with each other even though the instruments are precalibrated against a Jackson Candle turbidimeter. The Jackson Candle turbidimeter, the chosen instrument due to its ability to produce good results, is limited by a lower reading of 25 units. Therefore, nephelometers must be used by laboratories to analyze turbidities of lower values (*Standard Methods*, 14th Edition, 1975).

    b. Discrepancies may result from the use of suspensions of particulate matter that have different optical properties for preparation of instrumental calibration curves (*Standard Methods*, 14th Edition, 1975).

3. Salinity (February 3, 1981) - readings from the DOE salinometer were consistently lower than the ITT values. Review of first-day data (February 2, see Table 2) indicated that readings were much closer. This suggests that the WDOE salinometer may have been malfunctioning on the second day of the survey.

4. Temperature (February 3, 1981) - WDOE results are consistently lower than ITT and lower than the previous day even though

conditions were similar. ITT results for the second day compare favorably with first-day results. WDOE temperature readings were taken using the salinometer that also displayed depressed values for salinity, further suggesting that the meter was malfunctioning on the second day of the survey.

5. PBI (February 2, 1981) - values were consistently higher for ITT Rayonier results for both days; however, the standard deviation in PBI values was large enough that a significant difference between laboratory results was not apparent for February 2 data even though the means appear to be different.

   Split water samples analyzed by ITT and WDOE laboratories suggest that PBI values below the Rennie Island discharge are similar to those found above the discharge with one exception. Station 001 (February 2, Table 2) surface sample displayed PBI values 20 times that found at station 005, suggesting that a source for the PBI is between the two stations. This increase may suggest the Rennie Island discharge is the contributing source. However, other factors indicate the discharge may only be a partial contributor. These are listed in the following text:

   a. The drogue study on February 3, 1981, indicates that the effluent plume remains close to the Rennie Island shoreline for some distance after discharge. The station 001 is located in mid north channel approximately 200 feet offshore and away from the plume pathway (Figure 1). This station may be influenced by other industrial discharges; e.g., Weyerhaeuser Company aeration pond which discharges treated SWL on the north channel.

   b. Sampling was carried out on maximum ebb tide, a condition not condusive to lateral mixing of discharge with mid-channel flow. The plume would tend to follow a straight line downstream course as indicated by the drogue study.

   c. SWL from the Rennie Island discharge may contribute to the higher PBI value found on February 2 at station 001. However, with present sampling methods it would be difficult to assign a value to the contribution.

      A discussion concerning the use of the Pearl-Benson Index (PBI) as an analytical method follows:

      PBI values are used to evaluate impact on receiving waters by SWL discharges. The values are a measure of light absorbency by SWL based on wavelengths of light (usually 4200 A), and a standard PBI value that was produced by combining SWL effluents from paper industries throughout the state (Felicetta and McCarthy, 1963).

The PBI standard is no longer available and therefore individual laboratories must create their own standard based on available technical information (Robb, S., personal communication, 1981). Therefore, PBI values between laboratories may differ; however, comparision among samples analyzed by a laboratory are considered useful for determining the presence and magnitude of the SWL concentration in a receiving water. PBI values are influenced by naturally occurring materials found in the receiving water that absorb light at similar wavelengths, such as tannins, nitrogen-containing compounds, and inorganics (Felicetta and McCarthy, 1963).

CONCLUSIONS

1. Chehalis River water quality in the vicinity of the Rennie Island outfall appeared to be good except for fecal coliforms which generally exceeded the water quality standard and PBI values which appear to be elevated at the discharge point and 200 feet downstream.

2. The drogue study indicates that the SWL plume remains close to the shoreline of Rennie Island (25 yards or less) for at least 1,500 feet below the outfall during ebb tide, with a river flow of 5,200 cfs.

3. ITT stations below the Rennie Island discharge are improperly placed to monitor the effluent in the river from the Rennie Island discharge.

4. Quality assurance suggests that analytical techniques are significantly different for turbidity and PBI (February 3, 1981, only). Sampling techniques may have resulted in significant differences in pH analysis.

RECOMMENDATIONS

1. ITT Rayonier routine monitoring stations 001, 002, and 003 should be placed closer to the Rennie Island shoreline to improve detection of the SWL discharge.

DC:cp

Attachments

REFERENCES

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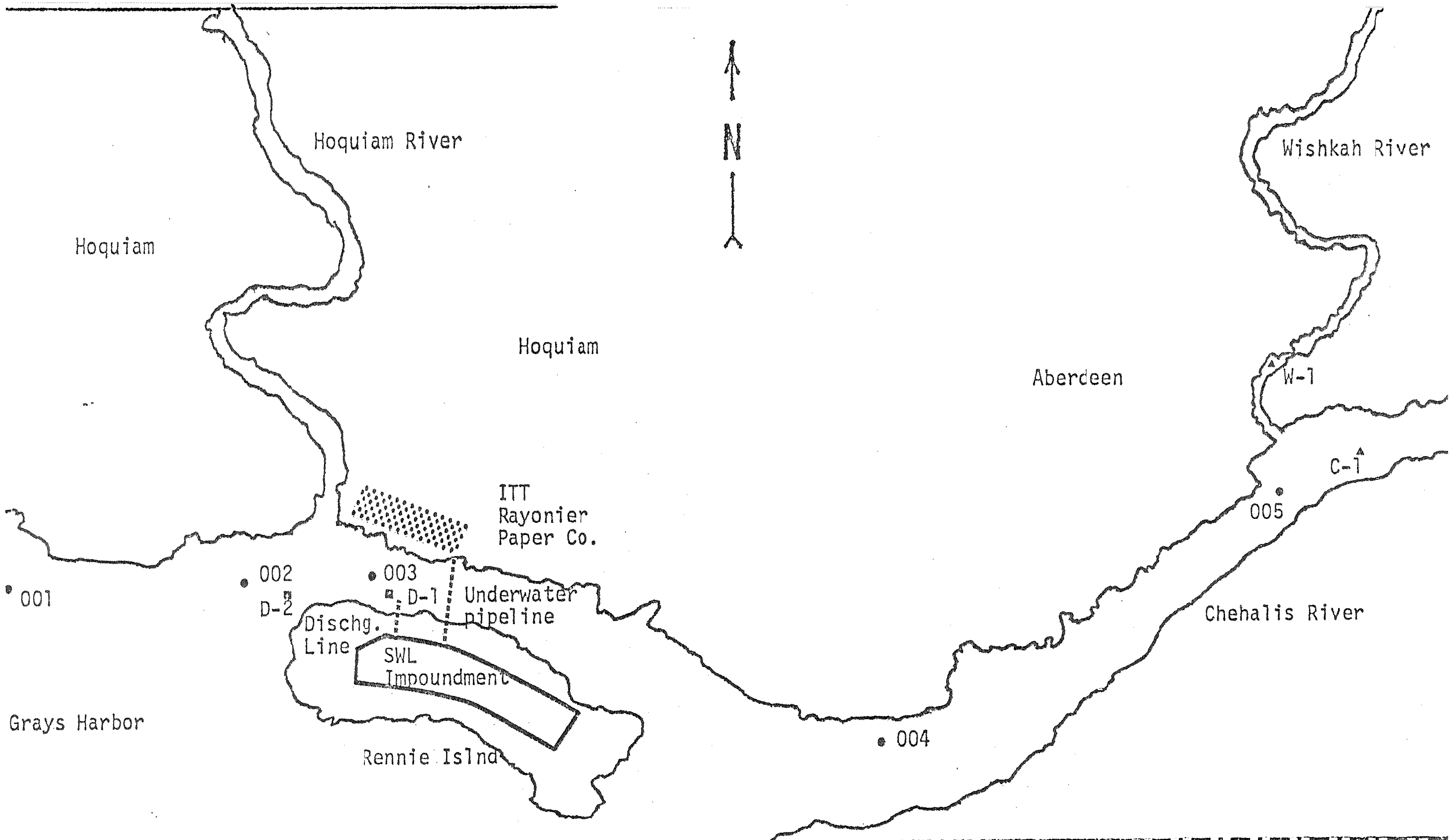

Figure 2. Map of survey area for Grays Harbor study, February 2 and 3, 1981.

LEGEND

● Receiving water stations for ITT Rayonier monitoring

▲ WDOE receiving water stations

▪ WDOE drogue study stations

Scale: 24,000:1

Table 1. - Continued.

Parameter	Location	Methods: ITT	Methods: WDOE	Reason for Sampling	Water Quality Standard (Class B)
Nutrients (mg/L) NO_3-N; NO_2-N; O-PO_4-P; T-PO_4P; NH_3-N	All stations	--	APHA, *et al.* (1976); EPA (1979)	Inorganic nutrients are most readily available for assimilation by marine plants. Excessive levels with abundant light may lead to massive algae production at the expense of other plants and animals. Ammonia (NH_3-N) is an immediate by-product of the breakdown of urine and is therefore useful to trace animal wastes in water. Excessive levels of un-ionized ammonia are toxic to aquatic organisms. But toxic levels in marine waters are controversial (EPA, 1976; Thurston *et al.*, 1979). Toxic levels are a function of pH, temperature, and salinity.	No numerical standard.
pH (S.U.)	All stations	Hydrolab	Orion digital pH meter	pH affects the carbonic acid-carbon dioxide balance in seawater. pH also affects the activity of un-ionized ammonia and sulfide.	Shall be within the range of 7.0 to 8.5 with a man-caused variation within a range of less than 0.5 unit.
Turbidity (NTU)	All receiving water stations	--	Turbidity: Hach Turbidimeter; TSS: APHA, *et al.* (1975); EPA (1979)	Measures water column transparency, light availability, and is an estimate of suspended material in water column. Sufficient light is essential to marine plant growth. Excessive suspended material may stress bottom-dwelling plants and animals by interference in filter feeding, and by light reduction, or smothering.	Not to exceed 10 NTU over background if background is 50 NTU or less or have more than a 20% increase in turbidity when the background turbidity is greater than 50 NTU.
Secchi Depth (m)	Discharge zone, ambient stations	--	Secchi disc lowered to depth of disappearance	Refer to turbidity comments above.	No standard.

Table 1. Parametric coverage and rationale for measuring each during Rennie Island Discharge study in Grays Harbor.

Parameter	Location	Methods ITT	Methods WDOE	Reason for Sampling	Water Quality Standard (Class B)
Temperature (°C)	All receiving water stations	Hydrolab	Beckman laboratory induction salinometer	Used with salinity to determine water density; temperature also affects gas soluability and rates of biological processes.	Not to exceed 19°C due to human activities. (t = 16/T)
Salinity (0/00)	All receiving water stations	Hydrolab (chlorinity)	Beckman laboratory induction salinometer	Used to trace passage of fresh-water through marine waters, mixing rates, and density distribution in water column.	No standard.
Dye (ug/L)	Discharge zone	--1/	Turner flourometer	Used as a water movement tracer and gauge of dilution and mixing processes downstream from discharge point.	N/A2/
Fecal Coliform (FC/100 ml)	All stations	--	APHA, *et al.* (1976); EPA (1979)	Indicator of presence of sewage wastes from humans and other warmblooded animals.	Not to exceed 100 FC per 100 ml; not more than 10% of samples to exceed 200 FC/100 ml.
% KES (KES/fc)	All stations	--	APHA, *et al.* (1976); EPA (1979)	Klebsiella pneumoniae are used as an indicator of waste discharge from certain pulp mill processes, and other sources conducive to growth.	Included in the fecal coliform count.
Dissolved O_2 (mg/L; % saturation)	All receiving water stations	Hydrolab	Winkler - azide modification (APHA, *et al.* 1976; EPA, 1979).	Elevated, relatively constant oxygen levels are essential for stable marine communities. Highly variable levels downstream from a source may be indicative of an organic load in excess of the ability of the system to assimilate it.	Shall exceed 5.0 mg/L or 70% saturation whichever is greater, except when the natural phenomenon of upwelling occurs. Natural D.O. levels can be degraded by up to 0.2 mg/L by man-caused activities.

1/ ITT did not sample or test parameter.

2/ Not applicable.

Table 1. - Continued.

Parameter	Location	Methods		Reason for Sampling	Water Quality Standard (Class B)
		ITT	WDOE		
Sulfite Waste Liquor (SWL) (mg/L)	All stations	--	Pearl-Benson Index (PBI): Perkin Elmer 360 Atomic Absorbtion spectrophotometer	SWL is a byproduct of the manufacture of paper from wood by the sulfite process. It also has a high oxygen demand (BOD) requirement when introduced into a receiving water. This results in a depletion of available oxygen for organisms in the system.	Toxic, radioactive, or deletrious material concentrations shall be below those which adversely affect public health during characteristic uses, or which may cause acute or chronic toxic conditions to the aquatic biota, or which may adversely affect characteristic water uses.
Biochemical Oxygen Demand (BOD_5) (mg/L)	Effluent	--	WDOE (1977)	Measures the dissolved oxygen consumed by micro-organisms while assimilating and oxidizing the organic matter in a sample.	N/A (Note: Permit limit for discharge states BOD must not exceed 50,000 lbs/day at minimum river flow of 5,000 cfs.
Color (units)	Effluent and Receiving Water	--	EPA (1976); Standard Methods (1971)	Color in water principally results from degradation processes in the natural environment. Most common in complex organic compounds. Sources include humic materials from tannins, humates, and decaying plants and animals, and industrial discharges. Waters shall be virtually free from substances producing objectional color. Increased color should not disrupt photosynthesis activity by more than 10% from seasonal norm. EPA (1976).	Aesthetic values shall not be reduced by dissolved, suspended, floating, or submerged matter not attributed to natural causes, so as to affect water use or taint the flesh of edible species.

Table 3. Summary and Comparison Chart for DOE and ITT Grays Harbor Survey Results, Basic Monitoring Stations, February 3, 1981.

Agency	Water Parameter	001 Hoquiam Fish Base (53) Surface	001 Hoquiam Fish Base (53) 10 m	002 Rennie Island (52) Surface	002 Rennie Island (52) 10 m	003 200 ft. below Discharge (200-B) Surface	003 200 ft. below Discharge (200-B) 10 m	004 Grays Harbor Port Terminal (685) Surface	004 Grays Harbor Port Terminal (685) 10 m	005 Aberdeen Railroad Bridge (33) Surface	005 Aberdeen Railroad Bridge (33) 10 m	Rennie Is. Effluent
DOE ITT	pH (Units)	7.7 7.9	7.8 8.2	7.5 7.9	7.6 8.1	7.5 7.9	7.8 8.2	7.5 7.7	7.6 7.9	7.6 7.8	7.5 7.9	2.5
DOE ITT	Turbidity (NTU)	11	25	7	8	9	28	10	23	10	18	58
DOE ITT	FC (col/100 ml)	520		720		640		560		100		<1.0
DOE ITT	% KES (KES/FC)	47		30		33		35		55		
DOE ITT	NO_3-N (mg/L)	0.38	0.22	0.40	0.16	0.40	0.20	0.44	0.20	0.56	0.50	
DOE ITT	NO_2-N (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
DOE ITT	NH_3-N (mg/L)	<0.01	0.03	0.06	0.08	<0.01	0.03	0.01	0.06	0.01	0.01	4.0
DOE ITT	O-PO_4-P (mg/L)	0.03	0.04	0.02	0.03	0.02	0.04	0.02	0.04	0.02	0.03	3.4
DOE ITT	T. Phos-P (mg/L)	0.05	0.06	0.04	0.05	0.05	0.06	0.05	0.06	0.04	0.06	5.0
DOE ITT	Color (Units)	33	21	38	42	33	17	33	33	29	29	10,000
DOE ITT	Salinity (o/oo)	15.1 21.3	22.4 28.0	14.6 19.1	23.9 26.0	14.2 19.1	23.3 25.7	11.3 15.0	20.6 23.1	6.8 8.1	12.1 17.7	
DOE ITT	PBI (mg/L)	14 7	9 56	14 31	36 59	14 30	5 62	5 64	14 52	9 72	9 32	120,000
DOE ITT	Temperature (°C)	6.8 7.9	6.9 8.2	6.3 7.7	6.8 7.9	6.5 7.7	6.8 7.9	6.2 7.5	6.7 8.0	5.8 7.2	6.0 7.3	
DOE ITT	Dissolved Oxygen (mg/L)	9.6 9.7	10.3 9.9	9.6 9.7	9.6 9.6	9.5 9.6	9.5 9.8	9.5 9.8	8.9 8.9	10.5 10.7	9.3 9.6	
DOE ITT	% Saturation Dissolved Oxygen	87.1 94.3	97.7 100.8	84.7 92.1	93.3 95.5	87.8 91.2	90.1 97.5	81.6 91.0	84.4 88.3	88.7 95.0	82.2 89.0	
DOE	BOD_5 (mg/L)											>6,900 (19,450 lbs/day)

Miscellaneous:

River flow (cfs) - 5,340
Effluent discharge (cfs) - .52
Dilution Ratio - 10,300:1

Table 2. Summary and Comparison Chart for DOE and ITT Grays Harbor Survey Results, Basic Monitoring Stations, February 2, 1981.

Agency	Water Parameter	001 Hoquiam Fish Base (53) Surface	001 Hoquiam Fish Base (53) 10 m	002 Rennie Island (52) Surface	002 Rennie Island (52) 10 m	003 200 ft. below Discharge (200-B) Surface	003 200 ft. below Discharge (200-B) 10 m	004 Grays Harbor Port Terminal (685) Surface	004 Grays Harbor Port Terminal (685) 10 m	005 Aberdeen Railroad Bridge (33) Surface	005 Aberdeen Railroad Bridge (33) 10 m	Rennie Is. Effluent
DOE	pH (Units)	7.5	7.9	7.7	7.7	7.8	7.9	7.6	7.7	7.6	7.5	2.6
ITT		8.1	8.1	7.7	8.0	7.7	8.0	7.7	7.8	7.6	7.7	
DOE	Turbidity (NTU)	14	18	13	33	16	29	16	36	10	36	54
ITT		4.8	4.4	5.7	18.0	7.2	17.5	7.2	15.0	7.5	9.4	
DOE	FC (col/100 ml)	360	64	300	100	170		150		240		3 est.
ITT												
DOE	% KES (KES/FC)	81	97	87	85	94			73		77	100
ITT												
DOE	NO_3-N (mg/L)	0.24	0.14	0.30	0.18	0.32	0.20	0.42	0.23	0.53	0.36	
ITT												
DOE	NO_2-N (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
ITT												
DOE	NH_3-N (mg/L)	0.01	<0.01	<0.01	0.02	0.02	0.02	0.02	0.05	0.02	0.06	3.2
ITT												
DOE	O-PO_4-P (mg/L)	0.03	0.04	0.03	0.05	0.03	0.05	0.03	0.05	0.03	0.05	3.2
ITT												
DOE	T. Phos-P (mg/L)	0.06	0.06	0.06	0.06	0.06	0.06	0.04	0.06	0.04	0.07	5.5
ITT												
DOE	Color (Units)	38	13	29	33	29	17	29	25	25	29	8,900
ITT												
DOE	Salinity (o/oo)	18.4	25.9	16.4	23.6	16.4	23.4	12.4	21.8	7.3	16.0	
ITT		25.3	27.1	16.1	25.6	17.3	25.3	14.3	24.2	7.4	16.8	
DOE	PBI (mg/L)	200	45	28	23	23	9	18	23	9	18	88,000
ITT		107	--	86	35	59	55	43	85	24	46	
DOE	Temperature (°C)	8.5	8.6	7.6	8.4	7.5	8.3	6.9	8.0	6.9	8.0	
ITT		8.2	8.4	7.8	8.2	7.7	8.0	7.5	8.3	7.0	7.5	
DOE	Dissolved Oxygen (mg/L)	9.5	9.5	9.5	9.3	9.4	8.3	9.9	8.6	10.6	10.0	
ITT		9.4	9.4	10.3	9.4	9.5	9.5	9.6	9.2	10.7	9.6	
DOE	% Saturation Dissolved Oxygen	90.4	94.4	90.1	90.1	89.4	90.1	88.1	83.6	91.8	93.7	
ITT		95.7	95.7	95.7	91.4	90.2	94.6	89.2	91.6	92.6	89.2	
DOE	BOD_5 (mg/L)											>6,900 (22,000 lbs/day)

Miscellaneous:

River Flow (cfs) - 5,630
Effluent discharge (cfs) - .59
Dilution Ratio - 9500:1

Table 5. Grays Harbor Paired Comparison Test Results for DOE and ITT Rayonier Samples Collected February 2 and 3, 1981.

Date	Parameter	DOE Mean ($\overline{X}$) ± Std. dev (s)	ITT Mean ± Std. dev (s)	Test Results
2/2	pH (S.U.)	7.69 ± .14	7.84 ± .19	Significant difference between laboratories
2/3	pH (S.U.)	7.61 ± .12	7.95 ± .16	Significant difference between laboratories
2/2	Turbidity (NTU)	22.10 ± 10.21	9.67 ± 5.20	Significant difference between laboratories
2/2	Salinity	18.16 ± 5.70	19.91 ± 6.49	No significant difference between laboratories
2/3	Salinity	16.43 ± 5.81	20.29 ± 5.91	Significant difference between labroratories
2/2	Temperature	7.87 ± .63	7.86 ± .44	No significant difference between laboratories
2/3	Temperature	6.46 ± .39	7.61 ± .62	Significant difference between laboratories
2/2	Dissolved Oxygen	9.55 ± .52	9.66 ± .47	No significant difference between laboratories
2/3	Dissolved Oxygen	9.62 ± .47	9.73 ± .44	No significant difference between laboratories
2/2	PBI	18.88 ± 6.88	55.38 ± 22.81	No significant difference between laboratories
2/3	PBI	12.90 ± 8.80	46.50 ± 20.40	Significant difference between laboratories
	PBI[1/]	1.13 ± .24	1.60 ± .34	No significant difference between laboratories

[1/] Pooled data for February 2, 1981 and February 3, 1981 transformed to log base 10.

Table 4. Summary and Comparison Chart for Grays Harbor Survey, Drogue Survey, and Input Streams, February 3, 1981.[1/]

Agency	Water Parameter	Station C-1 Chehalis River 600 ft. above Wishkah Confl.	Station W-1 Wishkah River at Wishkah Bridge	Station D-1 20 ft. below Rennie Is. Discharge	Station D-2 1500 ft. below Rennie Is. Discharge	Rennie Island Effluent
DOE ITT	pH (Units)	7.4	7.4	7.6 8.0	7.5 7.7	2.6
DOE ITT	Turbidity (NTU)	14	10	32	35	54
DOE ITT	Fecal Coliforms (col/100 ml)	520	390	340	340 est	3 est
DOE ITT	% KES (KES/FC)	66	62	84	84	100
DOE ITT	NO_3-N (mg/L)	0.55	0.51	0.38	0.39	
DOE ITT	NO_2-N (mg/L)	<0.01	<0.01	<0.01	<0.01	
DOE ITT	NH_3-N (mg/L)	0.02	0.02	0.03	0.04	3.2
DOE ITT	O-PO_4-P (mg/L)	0.03	0.02	0.04	0.04	3.2
DOE ITT	T. Phos-P (mg/L)	0.04	0.04	0.06	0.06	5.5
DOE ITT	Color (Units)	29	33	29	46	8,900
DOE ITT	Salinity (o/oo)	9.8	7.4	14.8	14.6	
DOE ITT	PBI (mg/L)	9	18	23 64	59 69	88,000
DOE ITT	Temperature (°C)	5.4[2/]	5.8[2/]	6.4 7.8	6.3 7.8	
DOE ITT	Dissolved Oxygen (mg/L)	8.6	10.3	9.5 9.6	8.8 9.6	
DOE ITT	% Saturation Dissolved Oxygen	75.7	90.7	88.2	88.2	
DOE ITT	Sp. Cond. (umhos/cm)	14,000	11,000			68,600
DOE ITT	BOD_5 (mg/L)					6,900 (22,000 lbs/day)

1/

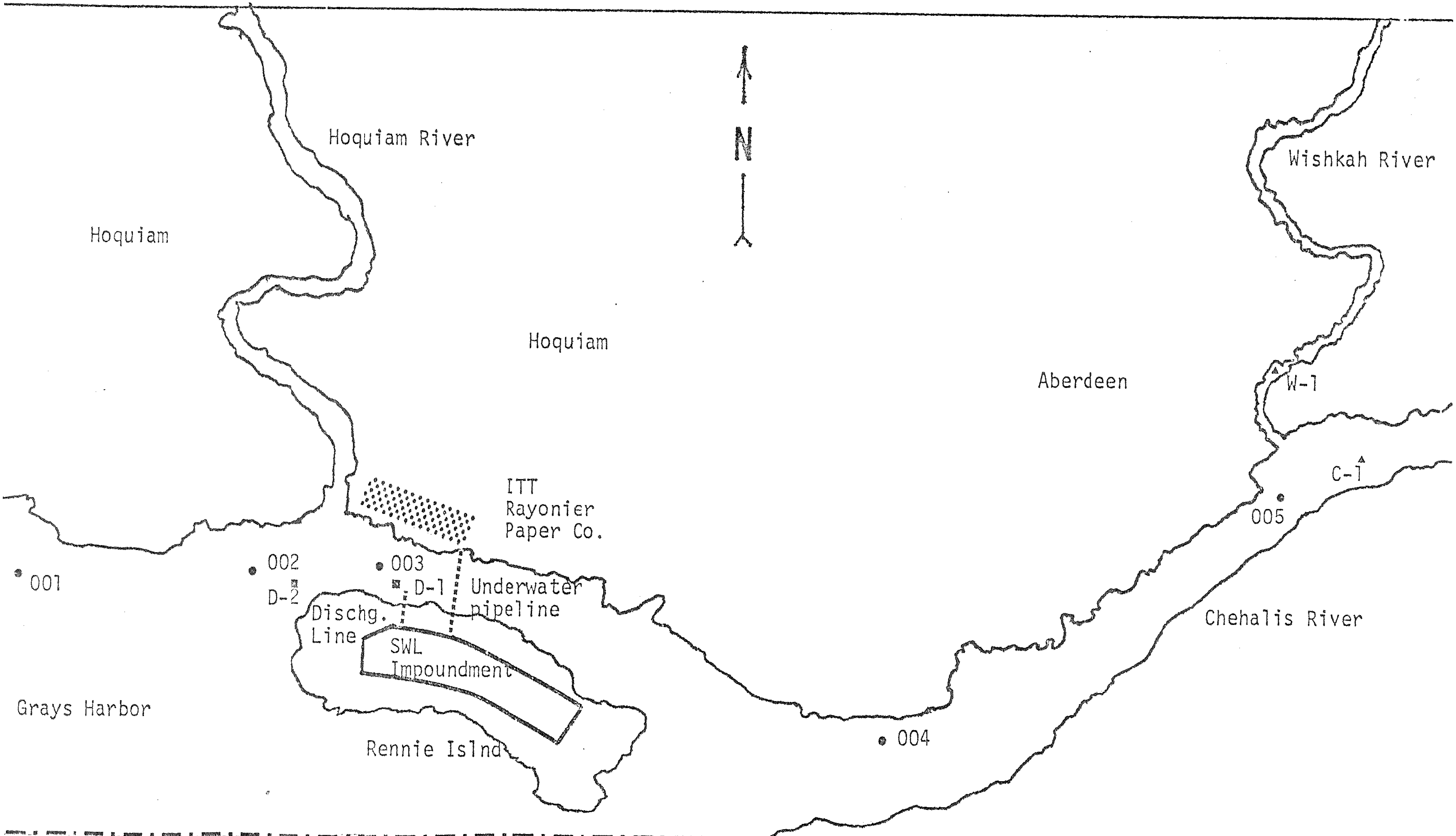

Figure 2. Map of survey area for Grays Harbor study, February 2 and 3, 1981.

LEGEND

- ● Receiving water stations for ITT Rayonier monitoring
- ▲ WDOE receiving water stations
- ■ WDOE drogue study stations

Scale: 24,000:1